DIALOG(R)File 345:Inpadoc/Fam.& Legal Stat

15384115

Basic Patent (No,Kind,Date): JP 11204433 A2 990730 <No. of Patents: 001>

METHOD OF MANUFACTURING SEMICONDUCTOR FILM AND LIQUID CRYSTAL DISPLAY (English)

Patent Assignee: TOKYO SHIBAURA ELECTRIC CO

Author (Inventor): YANO KENSAKU

IPC: *H01L-021/20; G02F-001/136; H01L-021/268

CA Abstract No: *131(10)136856Q; 131(10)136856Q

Derwent WPI Acc No: *C 99-484709; C 99-484709

Language of Document: Japanese

Patent Family:

Patent No	Kind	Date	Applic No	Kind	Date	
JP 11204433	A2	990730	JP 986626	A	980116	(BASIC)

Priority Data (No,Kind,Date):

JP 986626 A 980116

06262852 **Image available**

METHOD OF MANUFACTURING SEMICONDUCTOR FILM AND LIQUID CRYSTAL DISPLAY

PUB. NO.: 11-204433 [JP 11204433 A]
PUBLISHED: July 30, 1999 (19990730)
INVENTOR(s): YANO KENSAKU
APPLICANT(s): TOSHIBA CORP
APPL. NO.: 10-006626 [JP 986626]
FILED: January 16, 1998 (19980116)
INTL CLASS: H01L-021/20; G02F-001/136; H01L-021/268

ABSTRACT

PROBLEM TO BE SOLVED: To provide a method of manufacturing a semiconductor film capable of manufacturing a polysilicon film having an approximately uniform surface.

SOLUTION: A liquid crystal substrate 8 is beforehand formed on the surface of a glass substrate by forming an undercoat layer 6 made of silicon nitride and silicon oxide and amorphous silicon film 7 in order of mention. The liquid crystal substrate 8 is put on a stage 3 in an envelope 4 in which nitride gas is sealed at atmospheric pressure. The stage 3 is vibrated ultrasonically by an ultrasonic oscillating power supply at a frequency of approximately 30 MHz and reciprocated in a horizontal direction at a speed of an approximately 10 mm/sec. An excimer laser beam 12 emitted from a laser 13 and shaped through an optical system device 14 is projected onto the rectangular area on the liquid crystal substrate 8 through an optically transparent window 11. The amorphous silicon film 7 is melted and fluidized by the ultrasonic vibration, cooled and polycrystallized cooled after the irradiation. Impurities are not segregated at the crystal boundary and the silicon surface is formed flat.

(19) Japanese Patent Office (JP)

(12) Laid-Open Disclosure Public Patent Bulletin (A)

(11) Patent Application Laid-Open Disclosure No.: Hei 11-204433
(43) Laid-Open Disclosure Date: July 30, 1999
(51) Int. Cl.^{6}: H01L 21/30
G02F 1/136
H01L 21/268
Request for Examination: Not made
Number of Claim: 4
(21) Application No.: Hei 10-6626
(22) Application Date: January 16, 1998
(71) Applicant: 000003078
TOSHIBA CORPORATION
72-ban-chi, Horikawa-cyo, Saiwai-ku, Kawasaki-shi, Kanagawa-ken
(72) Inventor: Kensaku YANO
2-go, 9-ban, 1-cyo-me, Hatara-cyo, Fukaya-shi, Saitama-ken
c/o TOSHIBA FUKAYA ELECTRON FACTORY Co., LTD
(74) Attorney: Agent Jyo KABASAWA (and another two agents)

(54) [Title of the Invention]

METHOD OF MANUFACTURING SEMICONDUCTOR FILM AND LIQUID CRYSTAL DISPLAY DEVICE

(57) [Summary]

To provide a method of manufacturing a semiconductor film which comprises a polysilicon film having an almost leveled surface.

[Solving Means]

An undercoat layer 6 that is made from silicon nitride or silicon oxide in advance and an amorphous silicon film 7 are sequentially laminated and formed on the upper surface of a glass substrate so as to form a liquid crystal substrate 8. The liquid crystal substrate 8 is disposed on a stage 3 in a casing 4 in which nitrogen gas is filled and sealed under the atmospheric pressure. The stage 3 is oscillated with ultrasonic wave at an oscillation frequency of about 30 MHz by making use of an ultrasonic oscillation power supply 10 while the liquid crystal substrate 8 is moved in the horizontal direction at a rate of about 10 mm/sec. Excimer laser beam 12 that is emitted from a laser device 13 and processed into a rectangular shape via a light transmitting window 11 is irradiated on the liquid crystal substrate 8. The amorphous silicon film 7 is melted and is in a flowing state by the ultrasonic oscillation. After the termination of the irradiation of the excimer laser beam 12, the liquid-state amorphous silicon film is cooled and polycrystallized. Impurities are not

segregated in a crystal grain boundary, and, hence, the surface of the polysilicon film is leveled.

[Scope of Claim]
[Claim 1]
A method of manufacturing a semiconductor film, wherein a substrate is oscillated with ultrasonic wave when an amorphous silicon film that is deposited on the substrate is changed into a polysilicon film by the laser annealing.
[Claim 2]
A method of manufacturing a semiconductor film according to claim 1, wherein the substrate is at least oscillated with ultrasonic wave in not less than a 1/4 cycle in the horizontal direction of the substrate until the amorphous silicon film is changed into the polysilicon film by the laser annealing.
[Claim 3]
A method of manufacturing a semiconductor film according to claim 1, wherein the ultrasonic oscillation frequency of the substrate is set to not less than a unit of MHz.
[Claim 4]
A liquid crystal display device, comprising: a polysilicon film that is formed according to any one of the methods of manufacturing the semiconductor film of claim 1 or claim 3.

[Detailed Description of the Invention]
[0001]
[Technical Field to which the Invention Pertains]
The present invention relates to a method of manufacturing a semiconductor film in which an amorphous silicon film is changed into a polysilicon film by the laser annealing and to a liquid crystal display device.
[0002]
[Related Art]
In recent years, in a liquid crystal display device, a polysilicon film has been used for a semiconductor layer of a thin film transistor (TFT) over an insulating substrate as a substitute for an amorphous silicon film. With respect to the technique of forming the polysilicon film, a scanning circuit and a pixel that had been formed separately, can be simultaneously formed on the insulating substrate, thereby reducing the manufacturing cost significantly. Accordingly, the technique has been researched and developed actively.
[0003]
As a method of forming the above-mentioned polysilicon film, thermal chemical vapor deposition (expressed as thermal CVD) and laser

annealing are known.

[0004]

With respect to the thermal CVD, it employs a constitution in which the polysilicon film is formed on the insulating film by thermal decomposition of monosilane (SiH_4) gas. Since the insulating substrate is at least heated to not less than 550°C in the thermal CVD, however, a normal glass substrate cannot be used for the insulating substrate. An expensive quartz substrate must be used for the insulating substrate in the thermal CVD, and, hence, the thermal CVD is unavailable.

[0005]

On the other hand, with respect to the laser annealing, it can utilize a cheap glass substrate, and, hence, it has been a mainstream technique for forming the polysilicon film, at present. As shown in Fig. 6, in the laser annealing, a laser-annealing processing device 1 is used. The laser-annealing processing device 1 comprises a casing 4 that accommodates a stage 3 so as to place a glass substrate 2 thereon. The interior of the casing 4 is set to the atmospheric pressure and is hermetically filled with nitrogen gas (N_2) so as to be a nitrogen atmosphere.

[0006]

Note that the glass substrate 2 has a plain shape glass substrate with dimensions of 400 mm x 500 mm. As shown in Fig. 6 and Fig. 7, an undercoat layer 6 that is formed of silicon nitride (SiN_x: x is an integer) and silicon oxide (SiO_y: y is an integer) and an amorphous silicon film 7 with a film thickness of approximately 500Å are sequentially laminated and formed in advance on an upper surface of the glass substrate 2 so as to constitute a liquid crystal substrate 8.

[0007]

The undercoat layer 6 and the amorphous silicon film 7 are formed by sputtering. These films are further processed by plasma chemical vapor deposition (expressed as plasma CVD) using monosilane (SiH_4) gas so as to make the distribution of the film thickness become almost uniform. The plasma CVD is performed at a temperature of the glass substrate 2 of between 250°C and 350°C. The amorphous silicon film 7 thus formed by the plasma CVD contains about 10 atomic% of hydrogen. Before the amorphous silicon film 7 is polycrystallized and changed into the polysilicon film 7a by the laser annealing, i.e., by irradiating laser beam, a dehydrogenation process is conducted, for example, at 500°C, which is a temperature below the softening point of the glass substrate 2, so as to prevent hydrogen from suddenly boiling over during the irradiation of laser beam.

[0008]

The stage 3 accommodated in the casing 4 is movable in the horizontal direction at a rate of about 10 mm/sec by using a driving means, which is not shown in the drawings. A light transmitting window 11 is formed in the casing 4 in such a way that the light transmitting window is positioned above the stage 3 and is faced thereto.

[0009]

The laser-annealing processing device 1 is equipped with a laser device 13 that emits excimer laser beam 12 with a wavelength of about 308 nm. The laser device 13 is characterized by comprising, for example, about 20 nsec of pulse width, about 300 Hz of frequency, and about 200 W of an average output. The laser-annealing processing device 1 is equipped with an optical system device 14 which includes a longitudinal/horizontal axis homogenizer that processes the excimer laser beam 12 emitted from the laser device 13, a slit, an image focusing lens and beam profile. The excimer laser beam 12 is processed into a 0.5 mm x 150 mm rectangular laser beam by means of the optical system device 14 so as to irradiate the liquid crystal substrate 8, which is accommodated in the casing 4, with about 450 mJ/cm^2 of an irradiation energy density via the light transmitting window 11.

[0010]

The amorphous silicon film 7 is then polycrystallized, i.e., the amorphous silicon film 7 is changed into the polysilicon film 7a by irradiating the excimer laser beam 12 to the liquid crystal substrate 8, that is, by conducting the laser annealing. When the irradiation energy density of the excimer laser beam 12 is increased, a crystal grain of the polysilicon film 7a thus obtained by the laser annealing grows to in the order of 0.5 μm, thereby obtaining a good characteristic in which the crystal grain becomes a sufficient size that allows the mobility to be not less than 100 cm^2/V in the formation of the TFT structure. As shown in Fig. 7, however, projections 7b like mountain ranges are generated in the crystal grain boundary on the entire surface of the glass substrate 2. Concerning the projections 7b, if the film thickness of the amorphous silicon film 7 is set to about 500Å, the film thickness of the leveled surface portions (depression portions) of the thus-obtained polysilicon film 7a becomes approximately 500Å whereas the film thickness of the projection portions 7b thereof becomes approximately 1,000Å. It seems that the projections 7b are generated by segregating impurities in the crystal grain boundary when the amorphous silicon film is melted, crystallized, and cooled to solidify thereof, although it is not apparent. Further, the projections 7b cause the remainder of the film in processing and further cause the deterioration of the withstand pressure due to a damaged gate insulating film or the concentration of electrolysis, which results in the deterioration of workability and

reliability.

[0011]

Accordingly, it is thought that the chemical polishing method is used for the formation of a semiconductor. However, in case of using a liquid crystal substrate with large area as well as the liquid crystal substrate 8 for the liquid crystal display device, especially, it is very difficult to polish the entire surface of the substrate uniformly by the chemical polishing method.

[0012]

[Problem to be Solved by the Invention]

As set forth above, with respect to the laser annealing in which the amorphous silicon film 7 is polycrystallized by irradiating the excimer laser beam 12 to form the polysilicon film 7a, the projections 7b like mountain ranges are formed over the entire surface of the substrate that corresponds to the crystal grain boundary, and, hence, problems such as the remainder of the film, the damaged gate insulating film, and the deterioration of the withstand pressure, are caused.

[0013]

The present invention has been made in view of the above-described problems, and it is an object of the present invention to provide the method of manufacturing the semiconductor film, which provides the polysilicon film having an almost leveled surface, and to provide the liquid crystal display device.

[0014]

[Means for Solving the Problem]

According to the present invention, when an amorphous silicon film that is deposited over the substrate is changed into the polysilicon film by the laser annealing, the substrate is oscillated with ultrasonic wave. In addition, when the amorphous silicon film that is deposited over the substrate is changed into the polysilicon film by the laser annealing, the segregation of the impurities is prevented by oscillating the substrate with ultrasonic wave, thereby suppressing the generation of the projection portions over the surface of the substrate which are generated by the segregation of impurities.

[0015]

The ultrasonic oscillation of the substrate is at least carried out in not less than a 1/4 cycle in the horizontal direction of the substrate until the amorphous silicon film is changed into the polysilicon film by the laser annealing. The substrate is at least oscillated with ultrasonic wave in not less than a 1/4 cycle in the horizontal direction until the amorphous silicon film is changed into the polysilicon film by the laser annealing. As result, the surface of the polysilicon film, which is obtained by oscillating the substrate at least one time prior to the solidification of the projection portions generated due to the segregation of the impurities, is planarized.

[0016]

In addition, since the ultrasonic oscillation of the substrate is performed at not less than a unit of MHz, the polysilicon film having a leveled surface can be obtained by surely vibrating the substrate prior to the solidification of the projection portions due to the segregation of impurities.

[0017]

Furthermore, the present invention is provided with the polysilicon film, which is manufactured in accordance with the method of manufacturing the semiconductor film according to claim 1 or claim 3. The reliability of the liquid crystal display device is improved and the area of the displaying surface thereof is easily increased by utilizing the polysilicon film, which is formed by the method of manufacturing the semiconductor film according to claim 1 or claim 3, to the liquid crystal display device.

[0018]

[Embodiment Mode of the Invention]

An embodiment mode of a constitution of a manufacturing device of the method of manufacturing the semiconductor film according to the present invention will hereinafter be described with reference to the drawings.

[0019]

Note that same reference numerals are used for portions, which corresponds to those of the conventional examples illustrated in Fig. 6 and Fig. 7.

[0020]

In Fig. 1, reference numeral 1 denotes a laser-annealing processing device. The laser annealing processing device 1 includes a casing 4 that accommodates a stage 3 so as to place the glass substrate 2 on the stage 3. The interior of the casing 4 is set to the atmospheric pressure and is filled with nitrogen gas (N_2) and hermetically sealed so as to be a nitrogen atmosphere.

[0021]

The glass substrate 2 is a plain shape glass substrate with dimensions of 400 mm x 500 mm. As shown in Fig. 1 and Fig. 2, an undercoat layer 6 that is made from silicon nitride (SiN_x: x is an integer) or silicon oxide (SiO_y: y is an integer) in advance and an amorphous silicon film 7 with a thickness of about 500Å are sequentially laminated and formed on the upper surface of the glass substrate 2 so as to constitute a liquid crystal substrate 8.

[0022]

The undercoat layer 6 and the amorphous silicon film 7 are firstly formed by sputtering, and these films are then processed by the plasma chemical vapor deposition (expressed as plasma CVD) using monosilane (SiH_4) so as to make the distribution of the film thickness

become almost uniform. The plasma CVD is performed at a temperature of the glass substrate 2 of between 250°C and 350°C. The amorphous silicon film 7 formed by the plasma CVD contains about 10 atomic% of hydrogen. Accordingly, before the amorphous silicon film 7 is polycrystallized by the laser annealing, that is, by irradiating laser beam in such a way that the amorphous silicon film 7 is changed into the polysilicon film 7a, the amorphous silicon film 7 is dehydrogenated, for example, at a temperature of 500°C, which is the temperature below the softening point of the glass substrate 2, so as to prevent the hydrogen from suddenly boiling over at the irradiation of laser beam.

[0023]

The stage 3, which is accommodated in the casing 4, is movable in the horizontal direction at a rate of about 10 mm/sec by using a driving means, which is not illustrated in the drawings. Further, the stage 3 is connected to the ultrasonic oscillation power supply 10, which is disposed outside of the casing 4, via a cable 9. The stage 3 is oscillated with ultrasonic wave at a predetermined oscillation frequency. In the casing 4, the light transmitting window 11 is arranged above the stage 3 so as to face each other.

[0024]

The laser-annealing processing device 1 includes, for example, a laser device 13 that emits excimer laser beam 12 with a wavelength of about 308 mm. The laser device 13 is characterized by comprising, for instance, about 20 nsec of the pulse width, about 300 Hz of frequency, and about 200 W of average output. The laser-annealing processing device 1 includes an optical system device 14, which includes a longitudinal/horizontal axis homogenizer for processing the excimer laser beam 12 emitted from the laser device 13, a slit, a image focusing lens, and a beam profile. The light optical system 14 processes the excimer laser beam 12 such that the excimer laser beam 12 is irradiated with the dimensions of about 0.5 mm x 150 mm in a rectangular shape at the irradiation energy density of about 450 mJ/cm^2 via the light transmitting window 11 on the liquid crystal substrate 8, which is accommodated in the casing 4.

[0025]

Next, an operation of polycrystallizing the amorphous silicon film 7 in accordance with the laser annealing by the laser-annealing processing device 1 will be described with reference to the drawings.

[0026]

At first, the undercoat layer 6 that is made from silicon nitride (SiN_x: x is an integer) or silicon oxide (SiO_y: y is an integer) in advance and the amorphous silicon film 7 with a thickness of about 500Å are sequentially laminated and formed on the upper surface of the planar glass substrate 2 having the dimensions of 400 mm x 500 mm, thereby

forming the liquid crystal substrate 8. The liquid crystal substrate 8 is disposed on the stage 3. The interior of the casing 4 is set to the atmospheric pressure and is filled with nitrogen gas (N_2) and hermetically sealed therein.

[0027]

As shown in Fig. 3, the stage 3 is oscillated with ultrasonic wave at the oscillation frequency of, for example, about 30 MHz by means of the ultrasonic oscillation power supply 10. At this point, while moving the stage 3 in the horizontal direction at a rate of, for instance, about 10 mm/sec, the excimer laser beam 12, which is irradiated from the laser device 13 and processed into a rectangular excimer laser beam having the dimensions of about 0.5 mm x 150 mm via the optical system device 14, is irradiated on the liquid crystal substrate 8 through the light transmitting window 11 of the casing 4.

[0028]

By irradiating the excimer laser beam 12, the temperature of the amorphous silicon film 7, which is the temperature of the upper surface of the liquid crystal substrate 8, is immediately increased from the irradiation start time t1 as depicted in Fig. 4. When the temperature of the amorphous silicon film 7 is reached to 1,414°C of the melting point of silicon at the time t2, the amorphous silicon film 7 becomes to be melted. Until the time t3 in which the amorphous silicon film 7 is completely melted, the temperature thereof is kept constant. When the amorphous silicon film 7 is completely melted, the temperature of the amorphous silicon film 7 is further increased until the pulse terminating time t4 in which the irradiation of the excimer laser beam 12 is stopped. After the termination of irradiating the excimer laser beam 12, the melted amorphous silicon film becomes to be cooled and is solidified at the time t5 so as to generate a large number of crystals. Until the time t6, the temperature thereof is kept constant, and, hence, numerous crystals are grown. At the time t6, the amorphous silicon film 7 is completely solidified, thereby obtaining the polysilicon film 7a. The entire of the liquid crystal substrate 8 will hereinafter be cooled.

[0029]

The period between the time t1 and the time t6 in which the amorphous silicon film 7 is irradiated with the excimer laser beam 12 and is changed into the polysilicon film 7a is different depending on the presence or the kind of the undercoat layer 6, the atmosphere around the liquid crystal substrate 8, and the thermal radiation conditions such as the pressure conditions of an atmospheric pressure, a vacuum state or the like. In the aforementioned conditions of the embodiment mode, it is assumed that the time between t1 and t6 is set

to about a unit of 100 nsec.

[0030]

While the amorphous silicon film 7 is irradiated with the excimer laser beam 12 and is changed into the polysilicon film 7a, the liquid crystal substrate 8 that is disposed on the stage 3 is oscillated with the ultrasonic wave at the oscillation frequency of about 30 MHz. The polysilicon film 7a having a leveled surface can be thus obtained. The reason why the polysilicon film 7a having the leveled surface is obtained is assumed that the amorphous silicon film that is melted by the ultrasonic oscillation becomes in a liquid state due to the ultrasonic oscillation and the segregation of the impurities is prevented, which causes phenomena in which the projection portions generated by the segregation of the impurities on the surface of the substrate are suppressed.

[0031]

During the period between t1 and time t6 of in the order of a unit of 100 nsec in which the above-described polysilicon film 7a is obtained, it is necessary to oscillate the liquid crystal substrate 8 with ultrasonic wave at the oscillation frequency of not less than a 1/4 cycle, that is, a 1/4 oscillation, in the horizontal direction of the film such that the surface of the liquid crystal substrate 8 is flowed and is sufficiently leveled. This implies that the ultrasonic oscillation with the oscillation frequency of about not less than 2.5 MHz is required.

[0032]

Next, the relation between the conditions of the ultrasonic oscillation that is conducted in the laser annealing by means of the laser-annealing processing device 1 and the planarization of the surface of the obtained polysilicon film 7a will be described.

[0033]

The laser annealing is conducted with respect to the amorphous silicon film 7 under the following conditions of the ultrasonic oscillation: 0 of the oscillation frequency is not oscillated; the oscillation frequency is set to 1 MHz, 5 MHz, 10 MHz and 30 MHz, respectively. The result under the abovementioned conditions is illustrated in Fig. 5. In Fig. 5, a horizontal axis denotes the oscillation frequency at the 100 W of the output whereas the longitudinal axis denotes the height of the projection portions that occurs on the surface of the polysilicon film 7a.

[0034]

As apparent from the results illustrated in Fig. 5, until 1 MHz of the oscillation frequency, the projections are generated as well as the conventional technique in which the ultrasonic oscillation is not performed, and hence, an advantageous effect of the ultrasonic oscillation cannot be obtained. However, in a case where the

oscillation frequency is set to in the order of 5 MHz, the advantageous effect of the ultrasonic oscillation is obtained. When the oscillation frequency is set to 10 MHz, the height of the projections is reduced to 700 Å. When the oscillation frequency is set to 30 MHz, the surface of the polysilicon film is completely planarized.

[0035]

As set forth above, when the amorphous silicon film 7 is polycrystallized and changed into the polysilicon film 7a by the laser annealing, the segregation of the impurities is prevented and the projections generated by the segregation of the impurities on the surface is suppressed by conducting the ultrasonic oscillation, thereby permitting the formation of the polysilicon film 7a with the leveled surface. Accordingly, it is possible to prevent the remainder of the film or the deterioration of the withstand voltage due to the damaged gate insulating film constituting the thin film transistor (expressed as TFT), which will be formed on the surface in the latter process, and the electrolysis concentration, thereby allowing the enhancement of the uniformity of the processing and the reliability.

[0036]

While the amorphous silicon film 7 is irradiated with the excimer laser beam 12 to be crystallized and solidified so as to form the polysilicon film 7a, since the liquid crystal substrate 8 is at least oscillated with ultrasonic wave at the oscillation frequency of not less than a 1/4 cycle in the horizontal direction, the liquid crystal substrate 8 is oscillated at least one time prior to the solidification of the projection portions generated by the segregation of the impurities. As result, the surface of the polysilicon film 7a can be surely planarized.

[0037]

Further, by oscillating the liquid crystal substrate 8 with the ultrasonic wave by not less than a unit of MHz, the liquid crystal substrate 8 is surely oscillated and the generation of the projections due to the segregation of the impurities can be prevented, which surely allows the polysilicon film 7a with the leveled surface.

[0038]

In order to form the TFT structure of the liquid crystal display device, the method of changing the amorphous silicon film 7 into the polysilicon film 7a by the laser annealing is described in the aforementioned embodiment mode. Note that, the embodiment mode is applicable for any purpose in order to form the polysilicon film 7a having a leveled surface by the laser annealing.

[0039]

As has been explained heretofore, the amorphous silicon film 7 with a thickness of 500Å is irradiated with the excimer laser beam 12 having about 20 nsec of the pulse width and about 300 Hz of frequency,

and the substrate is at least oscillated with ultrasonic wave at the oscillation frequency of about not less than 2.5 MHz. However, the effective oscillation frequency of the ultrasonic oscillation is different depending on the film thickness of the amorphous silicon film 7 and the characteristics of the laser.

[0040]

[Effect of the Invention]

According to the present invention, when the amorphous silicon film that is deposited on the substrate is changed into the polysilicon film by the laser annealing, the substrate is oscillated with ultrasonic, which prevents the segregation of the impurities and suppresses the generation of the projections on the surface of the polysilicon film that is generated by the segregation of the impurities. As result, the polysilicon film having a leveled surface can be formed.

[0041]

Since the substrate is at least oscillated with ultrasonic in not less than a 1/4 cycle in the horizontal direction until the amorphous silicon film is changed into the polysilicon film by the laser annealing, the substrate is oscillated at least one time prior to the formation of the polysilicon film. The generation of the projections due to the segregation of the impurities can be suppressed, and, hence, the surface of the polysilicon film is surely planarized.

[0042]

Furthermore, since the substrate is oscillated with ultrasonic wave by not less than a unit of MHz, the substrate is surely oscillated prior to the solidification thereof, which allows the formation of the polysilicon film having a perfect leveled surface.

[Brief Description of the Drawings]

Fig. 1 is a block diagram showing the laser-annealing processing device of an embodiment mode according to the present invention;

Fig. 2 is a cross sectional view showing the liquid crystal substrate;

Fig. 3 is a cross sectional view showing the liquid crystal substrate on which the excimer laser beam is irradiated;

Fig. 4 is a graph explaining the change of the conditions of silicon due to the irradiation of the excimer laser beam;

Fig. 5 is a graph explaining the relationship between the oscillation frequency of the ultrasonic oscillation and the height of the projections during the laser annealing;

Fig. 6 is a block diagram showing the conventional laser-annealing processing device; and

Fig. 7 is a cross sectional view showing the liquid crystal substrate in which the amorphous silicon film is polycrystallized and is changed into the polysilicon film.

[Description of the Reference Numerals]

2: substrate
7: amorphous silicon film
7a: polysilicon film
10: ultrasonic oscillation power supply
12: laser beam